Information Sciences

Generic, Extensible, Configurable Push-Pull Framework for Large-Scale Science Missions

This framework also has been evaluated for data dissemination supporting the National Cancer Institute's early cancer detection research network.

NASA's Jet Propulsion Laboratory, Pasadena, California

The push-pull framework was developed in hopes that an infrastructure would be created that could literally connect to any given remote site, and (given a set of restrictions) download files from that remote site based on those restrictions.

The Cataloging and Archiving Service (CAS) has recently been re-architected and re-factored in its canonical services, including file management, workflow management, and resource management. Additionally, a generic CAS Crawling Framework was built based on motivation from Apache's open-source search engine project called Nutch. Nutch is an Apache effort to provide search engine services (akin to Google), including crawling, parsing, content analysis, and indexing. It has produced several stable software releases, and is currently used in production services at companies such as Yahoo, and at NASA's Planetary Data System.

The CAS Crawling Framework supports many of the Nutch Crawler's generic services, including metadata extraction, crawling, and ingestion. However, one service that was not ported over from Nutch is a generic protocol layer service that allows the Nutch crawler to obtain content using protocol plug-ins that download content using implementations of remote protocols, such as HTTP, FTP, WinNT file system, HTTPS, etc. Such a generic protocol layer would greatly aid in the CAS Crawling Framework, as the layer would allow the framework to generically obtain content (i.e., data products) from remote sites using protocols such as FTP and others. Augmented with this capability, the Orbiting Carbon Observatory (OCO) and NPP (NPOESS Preparatory Project) Sounder PEATE (Product Evaluation and Analysis Tools Elements) would be provided with an infrastructure to support generic FTP-based pull access to remote data products, obviating the need for any specialized software outside of the context of their existing process control systems.

This extensible configurable framework was created in Java, and allows the use of different underlying communication middleware (at present, both XML-RPC, and RMI). In addition, the framework is entirely suitable in a multi-mission environment and is supporting both NPP Sounder PEATE and the OCO Mission. Both systems involve tasks such as high-throughput job processing, terabyte-scale data management, and science computing facilities. NPP Sounder PEATE is already using the push-pull framework to accept hundreds of gigabytes of IASI (infrared atmospheric sounding interferometer) data, and is in preparation to accept CRIMS (Cross-track Infrared Microwave Sounding Suite) data. OCO will leverage the framework to download MODIS, CloudSat, and other ancillary data products for use in the high-performance Level 2 Science Algorithm.

The National Cancer Institute is also evaluating the framework for use in sharing and disseminating cancer research data through its Early Detection Research Network (EDRN).

Dynamic Loads Generation for Multi-Point Vibration Excitation Problems

Marshall Space Flight Center, Alabama

A random-force method has been developed to predict dynamic loads produced by rocket-engine random vibrations for new rocket-engine designs. The method develops random forces at multiple excitation points based on random vibration environments scaled from accelerometer data obtained during hot-fire tests of existing rocket engines. This random-force method applies random forces to the model and creates expected dynamic response in a manner that simulates the way the operating engine applies self-generated random vibration forces (random pressure acting on an area) with the resulting responses that we measure with accelerometers. This innovation includes the methodology (implementation sequence), the computer code, two methods to generate the random-force vibration spectra, and two methods to reduce some of the inherent conservatism in the dynamic loads.

This methodology would be implemented to generate the random-force spectra at excitation nodes without requiring the use of artificial boundary conditions in a finite element model. More accurate random dynamic loads than those predicted by current industry methods can then be generated using the random force spectra. The scaling

method used to develop the initial power spectral density (PSD) environments for deriving the random forces for the rocket engine case is based on the Barrett Criteria developed at Marshall Space Flight Center in 1963. This invention approach can be applied in the aerospace, automotive, and other industries to obtain reliable dynamic loads and responses from a finite element model for any structure subject to multipoint random vibration excitations.

Optimal Control Via Self-Generated Stochasticity

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The problem of global maxima of functionals has been examined. Mathematical roots of local maxima are the same as those for a much simpler problem of finding global maximum of a multi-dimensional function. The second problem is instability — even if an optimal trajectory is found, there is no guarantee that it is stable. As a result, a fundamentally new approach is introduced to optimal control based upon two new ideas.

The first idea is to represent the functional to be maximized as a limit of a probability density governed by the appropriately selected Liouville equation. Then, the corresponding ordinary differential equations (ODEs) become stochastic, and that sample of the solution that has the largest value will have the highest probability to appear in ODE simulation. The main advantages of the stochastic approach are that it is not sensitive to local maxima, the function to be maximized must be only integrable but not necessarily differentiable, and global equality and inequality constraints do not cause any significant obstacles.

The second idea is to remove possible instability of the optimal solution by equipping the control system with a self-stabilizing device.

The applications of the proposed methodology will optimize the performance of NASA spacecraft, as well as robot performance.

Space-Time Localization of Plasma Turbulence Using Multiple Spacecraft Radio Links

This technology has applications in forecasting adverse effects on satellites.

NASA's Jet Propulsion Laboratory, Pasadena, California

Space weather is described as the variability of solar wind plasma that can disturb satellites and systems and affect human space exploration. Accurate prediction requires information of the heliosphere inside the orbit of the Earth. However, for predictions using remote sensing, one needs not only plane-of-sky position but also range information — the third spatial dimension — to show the distance to the plasma disturbances and thus when they might propagate or co-rotate to create disturbances at the orbit of the Earth. Appropriately processed radio signals from spacecraft having communications lines-of-sight passing through the inner heliosphere can be used for this space-time localization of plasma disturbances.

The solar plasma has an electron density- and radio-wavelength-dependent index of refraction. An approximately monochromatic wave propagating through a thin layer of plasma turbulence causes a geometrical-optics phase shift proportional to the electron density at the point of passage, the radio wavelength, and the thickness of the layer. This phase shift is the same for a wave propagating either "up" or "down" through the layer at the point of passage. This attribute can be used for space-time localization of plasma irregularities.

The transfer function of plasma irregularities to the observed time series depends on the Doppler tracking "mode." When spacecraft observations are in the two-way mode (downlink radio signal phase-locked to an uplink radio transmission), plasma fluctuations have a "two-pulse" response in the Doppler. In the two-way mode, the Doppler time series $y_2(t)$ is the difference between the frequency of the downlink signal received and the frequency of a ground reference oscillator. A plasma blob localized at a distance x along the line of sight perturbs the phase on both the up and down link, giving rise to two events in the two-way tracking time series separated by a time lag depending the blob's distance from the Earth: $T_2 - 2x/c$, where T_2 is the two-way time-of-flight of radio waves to/from the spacecraft and c is the speed of light.

In some tracking situations, more information is available. For example, with the 5-link Cassini radio system, the plasma contribution to the up and down links, $y_{up}(t)$ and $y_{dn}(t)$, can be computed separately. The times series $y_{up}(t)$ and $y_{dn}(t)$ respond to a localized plasma blob with one event in each time series. These events are also separated in time by $T_2 - 2x/c$. By cross-correlating the up and down link Doppler time series, the time separation of the plasma events can be measured and hence the plasma blob's distance from the Earth determined. Since the plane-of-sky position is known, this technique allows localization of plasma events in time and three space dimensions.